The psychological impact of traffic injuries sustained in a road crash by bicyclists: A prospective study

Craig, Ashley; Elbers, N.A.; Jagnoor, Jagnoor; Gopinath, Bamini; Kifley, Annette; Dinh, Michal; Pozzato, Ilaria; Ivers, Rebecca; Nicholas, Michael; Cameron, Ian

published in
Traffic Injury Prevention
2017

DOI (link to publisher)
10.1080/15389588.2016.1248760

document version
Publisher's PDF, also known as Version of record

Traffic Injury Prevention

ISSN: 1538-9588 (Print) 1538-957X (Online) Journal homepage: https://www.tandfonline.com/loi/gcpi20

The psychological impact of traffic injuries sustained in a road crash by bicyclists: A prospective study

A. Craig, N. A. Elbers, J. Jagnoor, B. Gopinath, A. Kifley, M. Dinh, I. Pozzato, R. Q. Ivers, M. Nicholas & I. D. Cameron

To cite this article: A. Craig, N. A. Elbers, J. Jagnoor, B. Gopinath, A. Kifley, M. Dinh, I. Pozzato, R. Q. Ivers, M. Nicholas & I. D. Cameron (2017) The psychological impact of traffic injuries sustained in a road crash by bicyclists: A prospective study, Traffic Injury Prevention, 18:3, 273-280, DOI: 10.1080/15389588.2016.1248760

To link to this article: https://doi.org/10.1080/15389588.2016.1248760

Accepted author version posted online: 20 Oct 2016.
Published online: 06 Feb 2017.

TRAFFIC INJURY PREVENTION
2017, VOL. 18, NO. 3, 273–280
http://dx.doi.org/10.1080/15389588.2016.1248760

Taylor & Francis
Taylor & Francis Group

The psychological impact of traffic injuries sustained in a road crash by bicyclists: A prospective study

A. Craig [a], N. A. Elbers[a], J. Jagnoor[a,b], B. Gopinath[a], A. Kifley[a], M. Dinh[c], I. Pozzato[a], R. Q. Ivers[b], M. Nicholas[d], and I. D. Cameron[a]

[a]John Walsh Centre for Rehabilitation Research, Kolling Institute of Medical Research, Sydney Medical School–Northern, The University of Sydney, St. Leonards, New South Wales, Australia; [b]The George Institute for Global Health, Sydney Medical School, The University of Sydney, Sydney, New South Wales, Australia; [c]Department of Trauma Services, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia; [d]Pain Management Research Institute, Kolling Institute of Medical Research, Sydney Medical School–Northern, The University of Sydney, St. Leonards, New South Wales, Australia

ABSTRACT

Objective: The objective of this study was to investigate the psychological impact of traffic injuries in bicyclists (cyclists) in comparison to car occupants who also sustained traffic injuries. Factors predictive of elevated psychological distress were also investigated.

Methods: An inception cohort prospective design was used. Participants included cyclists aged ≥17 years (mean age 41.7 years) who sustained a physical injury ($n = 238$) assessed within 28 days of the crash, following medical examination by a registered health care practitioner. Injury included musculoskeletal and soft tissue injuries and minor/moderate traumatic brain injury (TBI), excluding severe TBI, spinal cord injury, and severe multiple fractures. Assessment also occurred 6 months postinjury. Telephone-administered interviews assessed a suite of measures including sociodemographic, preinjury health and injury factors. Psychological impact was measured by pain catastrophization, trauma-related distress, and general psychological distress. The psychological health of the cyclists was compared to that of the car occupants ($n = 234$; mean age 43.1 years). A mixed model repeated measures analysis, adjusted for confounding factors, was used to determine differences between groups and regression analyses were used to determine contributors to psychological health in the cyclists 6 months postinjury.

Results: Cyclists had significantly better psychological health (e.g., lower pain catastrophizing, lower rates of probable posttraumatic stress disorder [PTSD], and lower general distress levels) compared to car occupants at baseline and 6 months postinjury. Factors predictive of cyclists' psychological distress included younger age, greater perceived danger of death, poorer preinjury health, and greater amount of time in hospital after the injury.

Conclusions: These data provide insight into how cyclists perceive and adjust to their traffic injuries compared to drivers and passengers who sustain traffic injuries, as well as direction for preventing the development of severe psychological injury. Future research should examine the utility of predictors of psychological health to improve recovery.

ARTICLE HISTORY
Received 13 April 2016
Accepted 12 October 2016

KEYWORDS
Cycling injuries; road crash; depression; trauma; distress; pain catastrophizing

Introduction

Cycling is an increasingly popular form of physical activity. However, cycling is associated with a high risk of traffic injuries due to the vulnerable nature of cyclists, who are largely unprotected on roads shared with motorized vehicles and other hazards (Marković et al. 2016; Rivara et al. 2015; Shinar 2012; Weijermars et al. 2016). In Australia, rates of injured cyclists have increased by 47% from 2000 to 2008 (Henley and Harrison 2009) and traffic injuries following a cycling crash can be severe, including face, head, and upper extremity injuries, and this is especially so after a collision with a car (Amoros et al. 2011; Cripton et al. 2015; De Rome et al. 2013; Dinh et al. 2015). Innovative education, infrastructure, and legislative strategies for improving the safety of cyclists on the road are occurring, though challenges still exist (Lawrence et al. 2015).

Given the increasing popularity of cycling and the high vulnerability to traffic injuries, it is prudent to investigate psychological health following such an injury. Surprisingly, research investigating the impact of traffic injuries on the psychological health of cyclists is rare. Traffic injuries are associated with a serious health burden, including mental health (Weijermars et al. 2016), and injuries like spinal cord injury (Craig et al. 2015; Hancock et al. 1993), traumatic brain injury (Vanderploeg et al. 2007), and musculoskeletal injuries (Elbers et al. 2015) are associated with substantial rates of elevated psychological distress. Furthermore, the increased risk to the psychological health of drivers and passengers (car occupants) of vehicles involved in a road crash has been established (Bryant et al. 2010; Mayou and Bryant 2002; Nhac-Vu et al. 2014; Sterling et al. 2003). However, there has been no study comparing the impact of traffic injuries on the psychological health of cyclists to the psychological health of car occupants who also sustain

CONTACT Professor Ashley Craig a.craig@sydney.edu.au John Walsh Centre for Rehabilitation Research, Kolling Institute of Medical Research, Sydney Medical School–Northern, The University of Sydney, Corner Reserve Road & First Ave., St. Leonards, NSW 2065, Australia.
Managing Editor David Viano oversaw the review of this article.

traffic injuries. Additionally, studies investigating predictors of psychological health in cyclists sustaining traffic injuries are scarce.To rectify this situation, a large prospective study is currently being conducted, designed to investigate factors that influence health and social recovery following a traffic injury, including injury severity, psychological health, utilization of health services, compensation claims processes, liability and fault, and legal representation (Jagnoor et al. 2014). Participants being studied include injured car occupants, pedestrians, motorcyclists, and cyclists (Jagnoor et al. 2014). The data presented in the current article form part of the Jagnoor et al. (2014) study. Therefore, the objectives of the current study include (1) determining the psychological health of cyclists who have sustained traffic injuries assessed within 28 days of the crash and 6 months later, (2) comparing the psychological health of cyclists to car occupants who have also sustained traffic injuries, and (3) determining predictors of psychological health in cyclists 6 months postinjury. It was hypothesized that (1) cyclists who sustain traffic injuries will have superior psychological health (e.g., lower psychological distress) compared to car occupants with similar traffic injuries and (2) sociodemographic, preinjury, injury, and psychosocial variables will be independent predictors of the psychological health of cyclists 6 months following a road crash.

Material and methods

Participants

Participants aged at least 17 years old were invited to participate in the study after experiencing a road crash resulting in a traffic injury. Comprehensive details of the study design have been previously reported (Jagnoor et al. 2014). Inclusion criteria included (a) the injury was sustained in a road crash and diagnosed by a medical practitioner or health practitioner within 28 days of the crash; (b) the injured person was a cyclist, driver, or passenger (car occupant), motor bike rider or pillion passenger, or pedestrian; (c) English speaking, and (d) the participant was a resident of New South Wales, Australia, with a valid Medicare number. Exclusion criteria consisted of the following: (a) the person had a neurodegenerative disease affecting ability to consent; (b) the person sustained a catastrophic injury such as severe traumatic brain injury, severe burns, an acute spinal cord injury, or severe multiple fractures resulting in significant hospitalization and incapacitation; (c) the traffic injury was the result of intentional self-harm; (d) death of an immediate family member occurred in the crash; and (e) the person sustained only minor soft tissue injuries such as bruises, abrasions, or cuts.

Recruitment was ongoing between August 2013 and July 2014 and included those who had been admitted to hospital emergency departments. Participants included 1,450 people potentially meeting inclusion/exclusion criteria admitted to an emergency department over the 12-month period. Figure 1 provides detail on study participation as well as the number who did not wish to participate. A final total of 748 participants who met inclusion/exclusion criteria were recruited and assessed at baseline, and this included 238 cyclists and 510 noncyclists. Noncyclists included car occupants, pedestrians, and motorbike riders. However, for the purposes of this article, only data for the cyclists (n = 238) and car occupants (drivers and passengers; n = 234) are presented. Table 1 shows sociodemographic and injury/health details for the 2 samples. Table 2 shows the types of injuries sustained in the 2 groups. For the car occupants, 181 completed the 6-month follow-up (a response rate of 77.4%) and for the cyclists, 208 completed the 6-month assessment (a response rate of 87.4%). Those with follow-up were older (43.3 versus 38.5 years, P = .009) and more likely to be born in Australia (74.8% versus 54.2%, P = .0002), have tertiary education (56.6 versus 39.8, P = .005), and report small or no perceived danger of death caused by the accident (65.6 versus 45.8, P = .0009). However, they did not differ significantly in gender distribution, paid work status, marital status, self-rated health, body mass index (BMI) category, presence of preinjury comorbidities, hospital admission, or multiple injuries following accident.

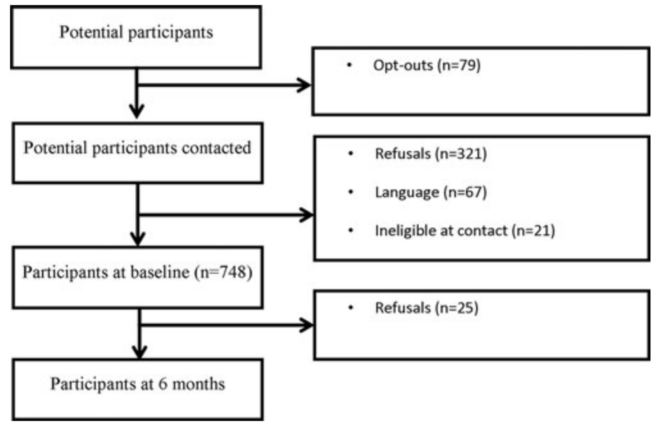

Figure 1. Flowchart of study participation.

Design and recruitment procedure

The study used an inception cohort design. Inception was defined as within 28 days of injury. Follow-up of participants occurred 6 months following the road crash. Data were entered on a secure online platform, called Research Electronic Data Capture (REDCap; Harris et al. 2009). Once screened, potential participants were sent a letter that described the study purpose and what was involved, inviting them to participate. Participants could opt out of the study via telephone or through e-mail. Participants who did not opt out within 1 week of the letter mail-out, were contacted by trained interviewers who obtained informed consent and conducted the structured baseline interview. Interviews were conducted by trained interviewers using computer-aided telephone interview. The study protocol was approved by a local human research ethics committee and conducted according to the principles expressed in the Declaration of Helsinki.

Measurements

Factors chosen as potential contributors/predictors of psychological health in cyclists were guided by prior studies that investigated predictors of psychological burden in car occupants. Factors studied in car occupants include sociodemographic (e.g., education, age), injury (e.g., presence of comorbidities, persistent pain, and days in hospital), preinjury health (e.g., prior psychological problems, prior traumas), and

Table 1. Sociodemographic and injury characteristics of car occupants (drivers/passengers) versus cyclists, with differences between groups shown using *t* tests or χ^2 tests as appropriate.

Characteristics	Car occupants ($n = 234$) Mean (SD)/*N* (%)	Cyclists ($n = 238$) Mean (SD)/*N* (%)	*P* value
Sociodemographics			
Age	43.1 (17.6)	41.7 (12.7)	.3
Sex			<.0001
Men	113 (48.3)	180 (75.6)	
Women	121 (51.7)	58 (24.4)	
Country of birth			.7
Other	69 (29.5)	67 (28.2)	
Australia	165 (70.5)	171 (71.9)	
Education			<.0001
Primary/secondary/technical	136 (58.1)	83 (34.9)	
Tertiary	98 (41.9)	155 (65.1)	
Marital status			.03
Married/de facto	113 (48.3)	132 (55.5)	
Never married	100 (42.7)	98 (41.2)	
	21 (9.0)	8 (3.4)	
Divorced/widowed/separated			
Paid work preinjury			<.0001
No	72 (30.8)	31 (13.0)	
Yes	162 (69.2)	207 (87.0)	
Preinjury health			
Self-reported health rating			.0001
Poor/fair	23 (9.8)	4 (1.7)	
Good/excellent	211 (90.2)	234 (98.3)	
BMI			.0009
Underweight	11 (4.9)	1 (0.4)	
Normal	98 (43.4)	128 (56.4)	
Overweight	117 (51.8)	98 (43.2)	
Preinjury comorbidities			<.0001
No	81 (34.8)	138 (58.0)	
Yes	152 (65.2)	100 (42.0)	
Injury			
Multiple injuries			.6
One injury	48 (20.5)	53 (22.3)	
Two or more injuries	186 (79.5)	185 (77.7)	
Hospital admission (≥12 h)			.1
No	126 (53.9)	146 (61.3)	
Yes	108 (46.2)	92 (38.7)	
Psychosocial			
Perceived danger of death			<.0001
None or small	116 (50.4)	177 (76.6)	
Moderate	32 (13.9)	31 (13.4)	
Large	82 (35.7)	23 (10.0)	

psychosocial factors (e.g., perceived life threat; Chossegros et al. 2011; Craig et al. 2015; Jeavons 2000; Ozer et al. 2003). Sociodemographic variables included, age, sex, education (university/tertiary or other), work status (paid work or other), country of birth, and marital status (married/defacto, divorced/widowed/separated, or never married). BMI was calculated from self-reported height and weight and classified according to World Health Organization guidelines (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html): <18.5 kg/m^2 (underweight), 18.5–24.9 kg/m^2 (normal), 25–29.9 kg/m^2 (overweight), ≥30 kg/m^2 (obese). Preinjury health-related quality of life (QOL) was assessed using the European Quality of Life–5 Dimensions (EQ-5D-3L) scale, administered at baseline (EuroQol Group 1990). The EQ-5D-3L includes 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is divided into 3 Likert-scale levels: *no problem, some problems*, and *extreme problems*. For the analyses, participants were divided into 2 subgroups, those indicating no problems versus those with any reported problems. A second measure of preinjury health involved participants reporting whether they have any of 18 preinjury comorbidities, including heart disease, stroke, arthritis, asthma, neurodegenerative diseases, visual or hearing impairments, chronic low back pain, or diabetes. This information was dichotomized as any preinjury comorbidity versus none. A third preinjury health measure involved participants rating their preinjury health on a 5-point scale from *poor* to *excellent*. This was dichotomized as low (rating of *poor* or *fair*) versus not low (rating of *good, very good*, or *excellent*).

Table 2. Frequencies of injury regions among car occupants and cyclists.

Injury region	Car occupants ($n = 234$) *N* (%)	Cyclists ($n = 238$) *N* (%)
Head	78 (33.3)	82 (34.5)
Neck	125 (53.4)	37 (15.5)
Shoulder	102 (43.6)	116 (48.7)
Arm	69 (29.5)	126 (52.9)
Chest	121 (51.7)	68 (28.6)
Upper back	84 (35.9)	27 (11.3)
Lower back	82 (35.0)	25 (10.5)
Leg	68 (29.1)	123 (51.7)

Crash-related characteristics included hours spent in hospital after the crash, dichotomized as spending <12 h or ≥12 h in hospital. Participants also self-reported type and number of traffic injuries (e.g., face, head, neck, upper back, lower back, chest, shoulder). Perceived danger of death during the road crash was also assessed on a 5-point Likert scale (0 = *none* to 5 = *overwhelming*). Participants' scores were divided into 3 subgroups including no or small perceived danger, moderate perceived danger, and great to overwhelming perceived danger. Pain intensity was measured using an 11-point Likert scale, where 1 = *no pain* and 11 = *worst pain ever*. Numerical pain rating scales have good test–retest reliability and validity (Jensen et al. 1999).

Psychological health was assessed by 3 measures providing an indication of psychological distress. First, the Pain Catastrophizing Scale (PCS) was used, providing an indication of pain-related distress (e.g., feeling helpless about their pain; Sullivan et al. 1995). The PCS is a 13-item, 5-point Likert scale (0–4), with a range of 0–52 with scores 34 or above indicating severely elevated pain-related catastrophic thinking when administered using 5-point Likert scales for each item (Sullivan et al. 1995). However, due to a transposing error, a 6-point Likert scale was used rather than the usual 5-point scale; that is, from 0 (*not at all*) to 5 (*all the time*). Therefore, for this study, scores ranged between 0 and 65, with a proportionally derived equivalent score of 42 or above representing clinically elevated pain catastrophization. This minor alteration of the Likert scoring did not alter the outcome of the analyses. Only the PCS total score data are presented. The PCS also indicates those who are experiencing almost no pain catastrophization (those responding *not at all*). The PCS has been shown to have adequate reliability, validity, and internal consistency (Sullivan et al. 1995; Van Damme et al. 2002).

The Impact of Events Scale—Revised (IES-R) is a 22-item self-report measure of trauma-related distress (Weiss and Marmar 1996), validated in people with traffic injuries (Beck et al. 2008). Respondents were asked to indicate their degree of distress during the past 7 days related to their recent road crash. It is a 5-point scale ranging from 0 (*not at all*) to 4 (*extremely*) for subscales Avoidance, Intrusion, and Hyperarousal. Domains are scored by determining the mean item score (Weiss and Marmar 1996). For the analyses, each domain had a range from 0 to 4, and the total possible score for the 3 domains was 12. We also report total IES-R scores and based on available norms; a total score of 45 or over out of a total score of 88 represented clinically elevated psychological distress related to the crash; that is, probable posttraumatic stress disorder (PTSD; Creamer et al. 2003). Higher scores indicate higher levels of distress. The IES-R has acceptable reliability and validity (Creamer et al. 2003; Weiss and Marmar 1996) and has been shown to detect traumatic stress in people experiencing road crashes, corresponding to a score of 6 or more on the 12-point scale (Beck et al. 2008).

The Depression Anxiety Stress Scale–21 (DASS-21) is a 21-item scale providing an overall assessment of general psychological distress (Crawford et al. 2011), as well as domains depressive mood, anxiety, and perceptions of stress (Henry and Crawford 2005; Lovibond and Lovibond 1995). Participants completed 4-point Likert items (0–3) assessing distress over the past week. Total scores range from 0 to 63 and are calculated by summing the scores for all 21 items (Lovibond and Lovibond 1995). The DASS-21 has acceptable reliability and validity (Henry and Crawford 2005). Based on DASS-21 norms, total scores of ≥32 represent clinically elevated levels of general psychological distress (Henry and Crawford 2005).

Statistical analysis

Baseline and 6-month postinjury characteristics of cyclists versus car occupants were summarized using descriptive statistics and differences between groups on these variables were compared using *t* tests or χ^2 tests where appropriate (see Table 1). With a sample size of over 200 in each group, the study provided sufficient statistical a priori power of over 90% (assuming an effect size of 0.3–0.5 for the outcome measures) to test study hypotheses. A linear mixed model analysis incorporating repeated measures was conducted to determine differences between groups (cyclists versus car occupants) over time (baseline–6 months) for pain catastrophizing (PCS), trauma related distress (IES-R), and general psychological distress (DASS-21) while controlling for possible confounders. A linear mixed model for repeated measures was the preferred approach because it includes all available data from baseline, handling the presence of missing follow-up data appropriately provided that missingness is not related to unobserved data values. With this approach, missing data at the 6-month assessment do not result in the whole case being eliminated from the analysis, as would happen if multivariate analysis of variance were used to handle the repeated measures. As shown in Table 1, cyclists had a higher proportion of males, higher education and paid work, higher preinjury QOL, and fewer comorbidities. Therefore, these variables were entered into the mixed model analysis as covariates. Additionally, each of the 3 outcome measures provides cutoff scores above which indicates severe levels of distress. These cutoff scores were used to dichotomize the samples into subgroups with severe levels of pain catastrophization, probable PTSD, and clinically elevated general psychological distress. Cutoff scores were based on relevant instrument norms and comparisons between groups were made using χ^2 tests.

To establish predictors of psychological health at baseline and 6 months postinjury in the cyclists, multivariable mixed model regression analyses were performed for each of the 3 psychological measures. Each model was built progressively, with significant ($P < .05$) and borderline ($P < .1$) sociodemographic factors entered first and then progressively expanding the model to include significant and borderline pre-injury– and injury-related factors and, finally, perceived threat of death in the crash. Statistical analyses were performed using SAS Version 9.4 (http://www.sas.com/en_au/software/analytics/stat.html).

Results

Table 1 shows that those in the cyclist group were more likely to be male ($P < .01$) than car occupants and have a higher frequency of tertiary education ($P < .01$) and preinjury paid work ($P < .01$), a lower frequency of being overweight ($P < .01$), a lower frequency of preinjury comorbidities ($P < .01$), and greater preinjury health ratings ($P < .01$). Cyclists were also less likely to report high perceived danger of death ($P < .01$). A description of the cycling accident was available for 196 of the cyclists. Cyclists whose accident involved a collision with a motorized vehicle ($n = 55$ or 28.1%) reported higher perceived danger of death than cyclists whose accident did not involve collision with a vehicle ($n = 141$, 71.9%). Cyclists who collided with a car were far more likely than other cyclists to report a great or overwhelming perceived danger of death in the accident (16.7% versus 4.4%, $P = .01$).

There were no significant differences between cyclists and the car occupants for the number of injuries sustained in the crash or time spent in hospital after the crash. This suggests that the 2 samples had similar injury severities. Table 3 shows unadjusted measures of pain intensity and psychological health for cyclists and car occupants at baseline and 6 months after the injury, with differences in mean scores between groups provided using *t* tests. Both groups reported lower pain intensity over time and these differences were significant ($P < .01$). The car occupants reported significantly higher pain at both time periods, though only marginally at baseline. Car occupants also reported significantly greater distress on the unadjusted values for the 3 measures.

Table 3. Unadjusted values for the pain intensity and psychological health of car occupants (drivers/passengers) and cyclists, with difference shown using *t* tests.

Pain intensity and mental health outcomes	Car occupants ($n = 234$) Mean (SD)	Cyclists ($n = 238$) Mean (SD)	*P* value
Pain intensity[a]			
Baseline	4.9 (2.4) $n = 198$	4.2 (2.1) $n = 218$	<.01
6 months	2.6 (2.7) $n = 170$	1.5 (1.9) $n = 197$	<.0001
Pain catastrophizing (PCS)			
Baseline	22.1 (17.7)	13.6 (12.8)	<.0001
6 months	21.2 (20.0)	9.8 (12.8)	<.0001
General distress (DASS-21)			
Baseline	15.3 (16.9)	8.1 (10.6)	<.0001
6 months	12.4 (16.7)	6.6 (11.3)	<.0001
Trauma-related distress (IES-R)			
Baseline	4.44 (3.34)	2.39 (2.14)	<.0001
6 months	2.80 (3.23)	1.39 (2.03)	<.0001

[a] Reduced participants given that many experienced no pain.

Table 4. Mean differences in psychological health of car occupants (drivers/passengers) and cyclists postinjury, adjusted for demographic factors and preinjury health using linear mixed models with repeated measures.[a]

	Mean difference by crash type		Mean difference by time point	
	Cyclists vs. car occupants		6 months vs. baseline	
Outcome	β (SE(β))	*P* value	β (SE(β))	*P* value
Pain catastrophizing				
PCS[b]	− 7.59 (1.58)	<.0001	− 2.80 (0.82)	.0007
Trauma-related distress				
IES-R[c]	− 1.46 (0.26)	<.0001	− 1.19 (0.11)	<.0001
General distress				
DASS-21	− 5.32 (1.32)	<.0001	− 1.65 (0.57)	.004

[a] Each analysis is adjusted for age, sex, university education, work status, preinjury health-related QOL, and presence of comorbid conditions.
[b] The Pain Catastrophizing Scale was assessed among individuals who had reported any pain since their injury.
[c] For the IES-R outcome only, linear mixed modeling showed significantly greater improvement with time in car occupants than in cyclists (mean difference in IES-R at 6 months versus baseline of −1.52 in car drivers/passengers compared with −0.8867 in cyclists, $P = .003$).

Table 4 shows mean differences in the 3 psychological measures between groups and over time after adjusting for factors that were found to be significantly different between the groups; that is, age, sex, education, preinjury health-related QOL, the presence of comorbidities, and paid work. Cyclists had significantly lower pain catastrophizing, lower trauma-related distress, and lower general psychological distress at both time points ($P < .01$). Changes over time in pain catastrophizing, trauma distress, and general psychological distress from baseline to 6 months postinjury were also analyzed in the linear mixed model analysis, while adjusting for the same covariates. Each psychological measure for the 2 groups showed significant improvement with time ($P < .01$). For trauma-related distress, the modeling showed significantly greater improvement with time in the car occupants than in the cyclists (mean difference in IES-R at 6 months versus baseline of −1.52 in car occupants versus −0.88 in cyclists, $P = .003$).

Table 5 shows clinically elevated rates of pain catastrophization, probable PTSD, and general psychological distress for both groups at baseline and 6 months postinjury. Significant differences are indicated by χ^2 analyses. At baseline and 6 months, significantly elevated rates of pain catastrophization, probable PTSD, and general psychological distress were found for the car occupants compared to cyclists, based on clinical cutoff norms for the 3 scales (Lovibond and Lovibond 1995; Sullivan et al. 1995; Weiss and Marmar 1996). For instance, probable rates of PTSD for the cyclists decreased from 8.1 to 4.8% by 6 months after the injury, whereas probable rates of PTSD remained significantly elevated in the car occupants over time in comparison (32.1% down to 20.1%). Importantly, similar results were found when the cutoff was based on the mean + 1 SD derived from the data.

Table 5. Percentages of the 2 groups with clinically elevated pain catastrophizing (PCS scores ≥ 42), trauma distress related to the crash (IES-R scores ≥ 6), and general psychological distress (DASS-21 scores ≥ 32), with χ^2 tests of association.

Psychological health	Car occupants ($n = 234$) *n* (%)	Cyclists ($n = 238$) *n* (%)	*P* value
Pain catastrophizing[a]			
Baseline	36 (18.3)	11 (5.1)	<.0001
6 months[b]	21 (16.9)	8 (4.9)	.0008
Trauma distress			
Baseline	75 (32.1)	19 (8.1)	<.0001
6 months[b]	36 (20.1)	10 (4.8)	<.0001
General psychological distress			
Baseline	45 (19.2)	13 (5.5)	<.0001
6 months[b]	23 (12.8)	12 (5.8)	.016

[a] Lower participant numbers for pain catastrophizing because these questions were only answered by those reporting pain. Baseline: car occupants $n = 197$, cyclists $n = 218$; 6 months: car occupants $n = 124$, cyclists $n = 163$.
[b] Participant numbers at 6 month follow-up: car occupants $n = 181$, bicyclists $n = 208$.

Table 6 shows multivariable mixed model regression analyses among cyclists, using the baseline and 6-month time points, for predictors of pain catastrophizing, distress related to trauma of the crash, and general psychological distress, respectively. Significant predictors of pain catastrophization included the number of comorbid conditions ($P < .05$), preinjury health-related QOL ($P < .05$), and moderate or large perceived danger of death ($P < .05$). Significant predictors of trauma distress included preinjury health-related QOL ($P < .01$), hospital admission ($P < .05$), preinjury comorbid conditions ($P < .05$), the presence of head or neck injury ($P < .05$), and moderate or large perceived danger of death ($P < .01$). Predictors of general psychological distress included younger age (17–24 years; $P < .05$), preinjury health-related QOL ($P < .01$), preinjury comorbid conditions ($P < .05$), presence of head/neck injury ($P < .01$), and large perceived risk of danger of death ($P < .01$).

Discussion

The cyclists sustained a similar severity of traffic injuries as the car occupants; for example, they spent comparable time in hospital and were not significantly different for number of injuries sustained. Nevertheless, the cyclists had substantially better psychological health when assessed within 28 days of the crash and 6 months after the crash. Cyclists catastrophized significantly less about their pain and reported significantly less trauma-related and general psychological distress at both time periods. Furthermore, these differences were found even after adjusting for potential confounding factors such as education, sex, employment, and preinjury health. Higher levels of education, health status, male sex, and employment are all factors that can act to protect a person against poor psychological health (Bonanno et al. 2007; Craig et al. 1996). The resilience of the cyclists was also demonstrated by their substantially lower rates of clinically elevated pain catastrophization, probable PTSD, and general distress (see Table 5).

However, sustaining injury in a traumatic road crash was shown to be associated with a psychological cost for both groups. For instance, scores for the DASS and IES-R were elevated in comparison to norms for both groups, and almost 10% of the cyclists had probable PTSD soon after the road crash, reducing to around 5% after 6 months, whereas over 30% of the car occupants had probable PTSD, reducing to 20% after 6 months. A cautious interpretation of the superior psychological health of the cyclists may be that engaging in a physical activity (cycling)

Table 6. Multivariable linear mixed models of contributing factors to pain catastrophizing (PCS), trauma-related psychological distress (IES-R), and general psychological distress (DASS-21) among cyclists ($n = 238$).[a]

Variables	PCS[b]		IES-R		DASS-21	
	β (SE(β))	*P* value	β (SE(β))	*P* value	β (SE(β))	*P* value
Time point						
6 months vs. baseline	− 3.74 (1.01)	.0003	− 0.87 (0.13)	<.0001	− 1.26 (0.71)	.08
Demographics						
Paid work	− 4.00 (2.18)	.07				
Age						
17–24			0.75 (0.42)	.07	5.20 (2.02)	.01
25–44			0 (ref)		0 (ref)	
45+			− 0.07 (0.24)	.7	− 1.11 (1.17)	.3
Male sex			− 0.31 (0.27)	.2	− 1.97 (1.30)	.13
Preinjury health						
Health-related QOL (EQ5D)	− 3.53 (1.75)	.045	− 1.08 (0.28)	.0001	− 8.82 (1.36)	<.0001
Comorbid conditions	3.69 (1.57)	.02	0.58 (0.25)	.02	2.50 (1.20)	.04
Injury						
Hospital admission (≤12 vs. ≥12 h)	2.57 (1.49)	.09	0.56 (0.24)	.02	1.96 (1.15)	.09
Head/neck injury	2.38 (1.48)	.1	0.49 (0.23)	.04	3.43 (1.12)	.002
Psychosocial						
Perceived danger of death						
Large	7.52 (2.50)	.003	1.69 (0.40)	<.0001	5.64 (1.92)	.004
Moderate	4.68 (2.20)	.03	0.97 (0.34)	.005	2.97 (1.65)	.07
Small or none	0 (ref)		0 (ref)		0 (ref)	

[a] ref = reference.
[b] The Pain Catastrophizing Scale was assessed among individuals who had reported any pain since their accident.

may provide some psychological protection (Cooney et al. 2013) from physical injury sustained during a life-threatening event requiring admission to hospital. Unfortunately, our data do not provide a causal explanation. Arguably, the influence of the superior psychological health of the cyclists may also be a product of their superior precrash functioning and overall psychological health. Healthier people (i.e., cyclists) may manage their injuries better because they are healthy preinjury, and cycling remains a choice that reflects their healthy lifestyle. Importantly, Chossegros et al. (2011) found that motorbike riders, who presumably as a group engage in lower levels of physical activity than cyclists, also have low risks of PTSD following an accident. Therefore, an alternative possible explanation for cyclists having superior psychological health contends that cyclists have a heightened awareness and acceptance of their vulnerability to sustaining an injury in a traffic accident and, as a consequence, they are more resilient when they sustain such an injury. Furthermore, their resilience may also be boosted by a commitment to cycling for environmental reasons. Arguably, therefore, the superior psychological health of cyclists may be a result of a combination of factors, such as frequent engagement in physical activity, superior preinjury health status, acceptance of risk, and a perceived higher meaning attached to the form of transport. Clarifying reasons for why cyclists cope better with traffic injuries is a matter for future research.

There is little information about factors that contribute to or predict psychological health following injury in cyclists. Findings revealed a number of factors that contribute to psychological health. Preinjury health was found to be associated with psychological health at baseline as well as predicting psychological health 6 months postinjury for all 3 psychological measures. Perceived danger of death also predicted psychological health in the 3 measures. As expected, perceived danger of death predicted probable PTSD at 6 months postinjury. This is consistent with the finding that those cyclists injured in a collision with a motor vehicle perceived the accident as far more dangerous than those who were injured in other ways. The presence of recurrent and persistent negative/distressing recollections of the trauma (in which one could have died) is suspected to play an important contributory role in the development of PTSD (Chossegros et al. 2011). Therefore, this research confirms perceived danger of death as a clinically valuable predictor of the risk of the development of PTSD, and this should be explored further in cyclists.

Other factors found to predict psychological distress included severity of the injury and the presence of neck and head injury. Prior research has also found that injury factors predict distress following trauma (Chossegros et al. 2011; Mayou and Bryant 2002). Older age has been found to be associated with cycling injury severity, due perhaps to decreasing physical health and the increasing risk of health conditions such as osteoarthritis and cardiovascular diseases (Chong et al. 2010; Marković et al 2016). However, we found that younger age contributed to elevated psychological distress at 4 weeks post road crash. Younger age has been found to be a higher risk of poor psychological health, though further research needs to be directed at clarifying mechanisms behind any age-related risk for anxiety and depression (Jorm 2000). Though the majority of these predictor factors are not amendable to change, a factor like "perceived danger of death" could be addressed by psychologically informed early intervention in cyclists (as well as car occupants). Given the increasing interest in cycling (Bassett et al. 2008), it is important that future research investigate the sensitivity and specificity of this group of factors for predicting psychological health outcomes in cyclists who have experienced traffic injuries.

A key strength of this study is its prospective design, recruitment strategy, and the collection of comprehensive health-related data associated with traffic injuries. Limitations require discussion. The inception cohort prospective design did not involve collecting noninjured controls. However, a strength of this design is its recruitment of well-defined participants (people injured in a motor vehicle crash meeting inclusion/exclusion criteria) recruited over time while assessing various outcomes and risk factors following a traumatic injury. Though recruitment from an emergency department remains a strength, such recruitment may well create bias in the samples. Future research may also need to recruit participants from non-hospital sources such as registered health or medical practitioners. Furthermore, data were not systematically collected on factors that may influence outcomes, such as the location or circumstance of injury; cycling intensity; the reason for riding, such as for sport, leisure, or transportation; the type of crash interactions involved; and procedures undergone in hospital. Longer term postinjury outcomes are also required to clarify how people recover and cope following injury in the longer term, and 12-month postinjury assessment is presently occurring.

There are several implications of these findings for cyclists and their communities. First, cycling is associated with substantial benefits to society such as reduced road congestion, lowered environmental and health costs, and improved physical and psychological health; further, nonmotorized forms of transport like cycling will lead to reduced road trauma (Bauman et al. 2008). However, safety concerns have been shown to be a major deterrent to cycling (Bauman et al. 2008). Therefore, communicating the findings of this article to the broader community that cycling can be associated with improved resilience when faced with trauma may serve to encourage greater engagement in cycling, thus producing greater benefits for society and the individual. Second, the financial and personal costs associated with cycling traffic injuries are likely to increase as cycling becomes a more popular form of transport, and the findings of this article do indicate that a minority of cyclists who sustain significant traffic injuries are at risk of developing elevated psychological distress. It would therefore be highly preferable if injured cyclists were made aware of the opportunity for early psychological intervention to prevent the development of disorders like PTSD or depression. This could be achieved through community education campaigns or adaptation of emergency department and compensation processes so that early psychological assessment was available to injured cyclists. Third, given that the presence of neck and/or head injury predicted elevated psychological distress, the importance of protecting cyclists from head injuries by, for instance, the wearing of helmets, is reinforced. In conclusion, it is hoped that these findings will encourage further research that investigates the effects of psychological and environmental factors on the impact of traffic injury–related trauma.

Funding

This research was funded by a competitive grant from the State Insurance Regulatory Authority Grant No. 12/327 (formerly the Motor Accident Authority NSW).

ORCID

A. Craig http://orcid.org/0000-0001-7647-7604

References

Amoros E, Chiron M, Thelot B, et al. The injury epidemiology of cyclists based on a road trauma registry. *BMC Public Health.* 2011;11:653–665.

Bassett DR, Pucher J, Buehler R, et al. Walking, cycling, and obesity rates in Europe, North America, and Australia. *J Physic Act Health.* 2008;5:795–814.

Bauman A, Rissel C, Garrard J, et al. Cycling: getting Australia moving—barriers, facilitators and interventions to get more Australians physically active through cycling. *Paper presented at: 31st Australasian Transport Research Forum; October 2–October 3* 2008; Gold Coast, Australia.

Beck JG, Grant DM, Read JP, et al. The Impact of Event Scale–Revised: psychometric properties in a sample of motor vehicle accident survivors. *J Anxiety Disord.* 2008;22:187–198.

Bonnano GA, Galea S, Bucciarelli A, et al. What predicts psychological resilience after disaster? The role of demographics, resources, and life stress. *J Consult Clin Psychol.* 2007;75:671–682.

Bryant RA, O'Donnell M, Creamer M, et al. The psychiatric sequelae of traumatic injury. *Am J Psychiatry.* 2010;167:312–320.

Chong S, Poulos R, Olivier J, et al. Relative injury severity among vulnerable non-motorised road users: comparative analysis of injury arising from bicycle–motor vehicle and bicycle–pedestrian collisions. *Accid Anal Prev.* 2010;42:290–296.

Chossegros L, Hours M, Charnay P, et al. Predictive factors of chronic post-traumatic stress disorder 6 months after a road traffic accident. *Accid Anal Prev.* 2011;43:471–477.

Cooney GM, Dwan K, Greig CA, et al. Exercise for depression. *Cochrane Database Syst Rev.* 2013;9:CD004366.

Craig A, Hancock K, Craig M. The Lifestyle Appraisal Questionnaire: a comprehensive assessment of health and stress. *Psychol Health.* 1996;11:331–343.

Craig A, Nicholson Perry K, Guest R, et al. A prospective study of the occurrence of psychological disorders and co-morbidities following spinal cord injury. *Arch Phys Med Rehabil.* 2015;96:1426–1434.

Crawford J, Cayley C, Lovibond PF, et al. Percentile norms and accompanying interval estimates from an Australian general adult population sample for self-report mood scales (BAI, BDI, CRSD, CES-D, DASS, DASS-21, STAI-X, STAI-Y, SRDS, and SRAS). *Aust Psychol.* 2011;46:3–14.

Creamer M, Bell R, Failla S. Psychometric properties of the Impact of Event Scale–Revised. *Behav Res Ther.* 2003;41:1489–1496.

Cripton PA, Shen H, Brubacher JR, et al. Severity of urban cycling injuries and the relationship with personal, trip, route and crash characteristics: analyses using four severity metrics. *BMJ Open.* 2015;5:e006654.

De Rome L, Boufous S, Georgeson T, et al. Bicycle crashes in different riding environments in the Australian Capital Territory. *Traffic Inj Prev.* 2013;15:81–88.

Dinh MM, Kastelein C, Hopkins R, et al. Mechanisms, injuries and helmet use in cyclists presenting to an inner city emergency department. *Emerg Med Australas.* 2015;27:323–327.

Elbers NA, Akkermans AJ, Lockwood K, et al. Factors that challenge health for people involved in the compensation process following a motor vehicle crash: a longitudinal study. *BMC Public Health.* 2015;15: 339–349.

EuroQol Group. EuroQol—a new facility for the measurement of health-related quality of life. *Health Policy.* 1990;16:199–208.

Hancock K, Craig AR, Tennant C, et al. The influence of spinal cord injury on coping styles and self-perceptions: a controlled study. *Aust N Z J Psychiatry.* 1993;27:450–456.

Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42:377–381.

Henley G, Harrison JE. *Serious Injury Due to Land Transport Accidents, Australia* 2006–07. Canberra: Australian Institute of Health and Welfare; 2009. Injury Research and Statistics Series No. 53. Cat. No. INJCAT 129, Canberra: AIHW.

Henry JD, Crawford JR. The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. *Br J Clin Psychol.* 2005;44:227–253.

Jagnoor J, Blyth F, Gabbe B, et al. Factors influencing social and health outcomes after motor vehicle crash injury: an inception cohort study protocol. *BMC Public Health.* 2014;14:199–207.

Jeavons S. Predicting who suffers psychological trauma in the year after a road accident. *Behav Res Ther.* 2000;38:499–508.

Jensen MP, Turner JA, Romano JM, et al. Comparative reliability and validity of chronic pain intensity measures. *Pain.* 1999;83:157–162.

Jorm AF. Does old age reduce the risk of anxiety and depression? A review of epidemiological studies across the adult life span. *Psychol Med.* 2000;30:11–22.

Lawrence BM, Stevenson MR, Oxley JA, Logan DB. Geospatial analysis of cyclist injury trends: an investigation in Melbourne, Australia. *Traffic Inj Prev.* 2015;16:513–518.

Lovibond SH, Lovibond PF. *Manual for the Depression Anxiety Stress Scales*. Sydney, Australia: Psychology Foundation; 1995.

Marković N, Pešić DR, Antić B, Vujanić M. The analysis of influence of individual and environmental factors on 2-wheeled users' injuries. *Traffic Inj Prev.* 2016;17:610–617.

Mayou R, Bryant B. Outcome 3 years after a road traffic accident. *Psychol Med.* 2002;32:671–675.

Nhac-Vu HT, Hours M, Chossegros L, et al. Prognosis of outcome in adult survivors of road accidents in France: one-year follow-up in the ESPARR cohort. *Traffic Inj Prev.* 2014;15:138–147.

Ozer EJ, Best SR, Lipsey TL. Predictors of posttraumatic stress disorder and symptoms in adults: a meta-analysis. *Psychol Bull.* 2003;129:52–73.

Rivara FP, Thompson DC, Thompson RS. Epidemiology of bicycle injuries and risk factors for seious injury. *Inj Prev.* 2015;21:47–51.

Shinar D. Safety and mobility of vulnerable road users: pedestrians, bicyclists, and motorcyclists. *Accid Anal Prev.* 2012;44:1–2.

Sterling M, Kenardy J, Jull G, et al. The development of psychological changes following whiplash injury. *Pain.* 2003;106:481–489.

Sullivan MJL, Bishop S, Pivik J. The Pain Catastrophizing Scale: development and validation. *Psychol Assess.* 1995;7:524–532.

Van Damme S, Crombez G, Bijttebier P, et al. A confirmatory factor analysis of the Pain Catastrophizing Scale: invariant factor structure across clinical and non-clinical populations. *Pain.* 2002;96:319–324.

Vanderploeg RD, Curtiss G, Luis CA, et al. Long-term morbidities following self-reported mild traumatic brain injury. *J Clin Exp Neuropsychol.* 2007;29:585–598.

Weijermars W, Bos N, Stipdonk H. Health burden of serious road injuries in The Netherlands. *Traffic Inj Prev.* 2016;17:863–869.

Weiss DS, Marmar CR. The Impact of Event Scale—Revised. In: Wilson J, Keane TM, eds. *Assessing Psychological Trauma and PTSD*. New York, NY: Guilford; 1996:399–411.